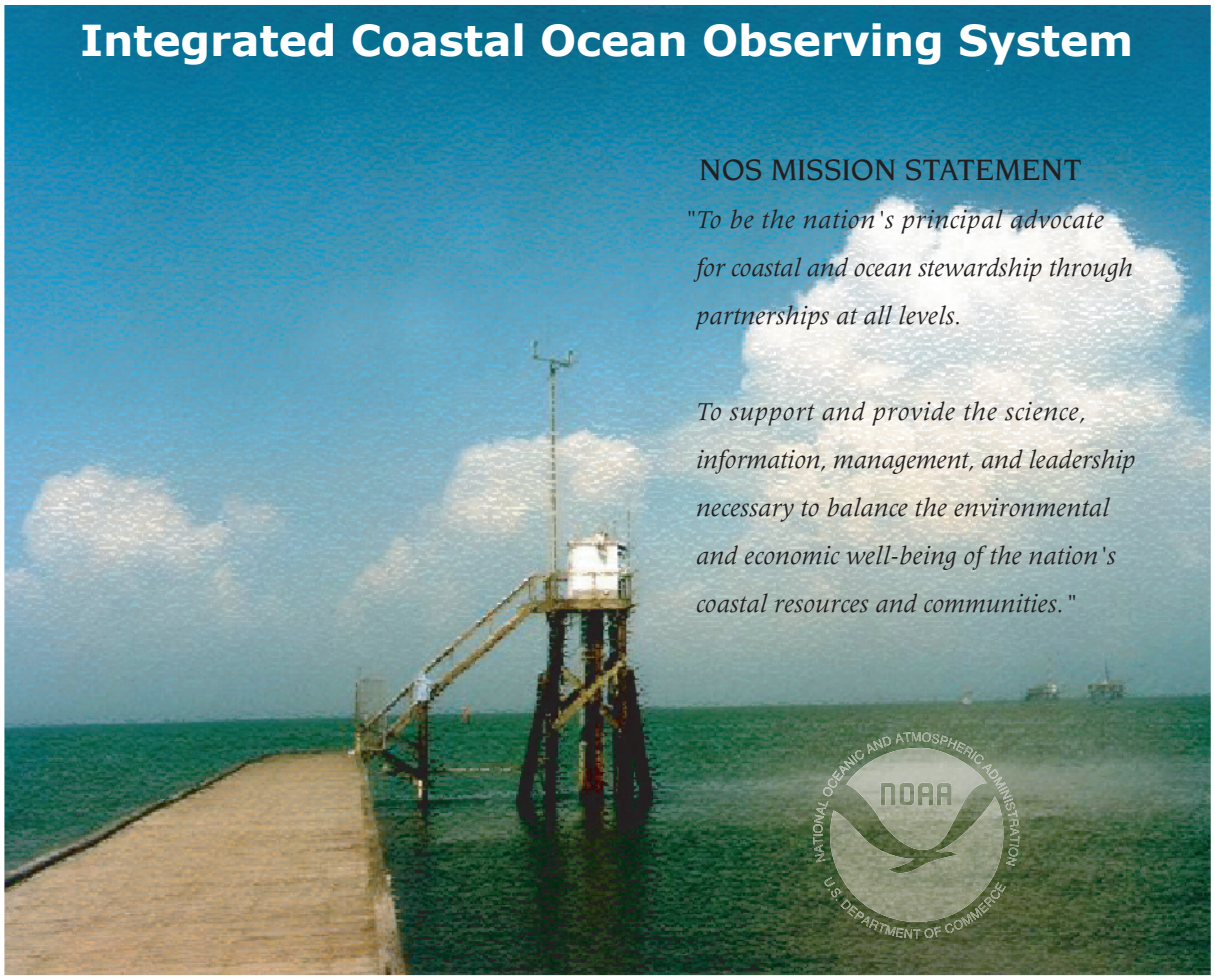
NOAA's NATIONAL OCEAN SERVICE

Contributions to an

Integrated Coastal Ocean Observing System



NOS MISSION STATEMENT

"To be the nation's principal advocate for coastal and ocean stewardship through partnerships at all levels.

To support and provide the science, information, management, and leadership necessary to balance the environmental and economic well-being of the nation's coastal resources and communities."

U.S. DEPARTMENT OF COMMERCE • NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
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NOAA Ocean Service

Contributions to an

Integrated Coastal Ocean Observing System

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Weeks Bay National Estuarine Research Reserve

CHARGE to the WORKING GROUP

In August 2001, NOS Acting Assistant Administrator Margaret Davidson directed a team of NOAA Ocean Service (NOS) staff to conduct an assessment of the Ocean Service's Contributions to an Integrated Coastal Ocean Observing System. The charge was to provide:

1) An inventory of the existing NOS' **operational** observing/monitoring systems, related data management and delivery capabilities and modeling capabilities;

2) An assessment of the potential contribution that these systems could make to a **national backbone** for the **coastal component** of IOOS, based on an analysis of existing gaps in current capabilities; and

3) Recommendations for priorities that expand NOS' existing ocean observing system components.

EXECUTIVE SUMMARY

In August 2001, NOAA Ocean Service (NOS) Acting Assistant Administrator Margaret Davidson directed an NOS team to provide an assessment of its current operational observational/monitoring systems and its contribution to a national Integrated Sustained Ocean Observing System (IOOS). The charge directed NOS to first develop an inventory of its existing observing systems, describing the purpose, character and scope of each system with respect to customers, observing platforms, data outputs, availability and delivery, and funding profiles. NOS programs would then be evaluated as IOOS "National Backbone" elements – i.e., observing systems that provide routine measurements of core variables and are supported by automated data delivery systems. This process and its preliminary findings provided input to the Ocean.US national workshop (March 2002) and helped support new efforts to implement a NOAA coastal observing system as requested by VADM Lautenbacher (US Navy Ret.).

KEY FINDINGS

NOS supports 28 coastal and ocean observation systems – a diverse portfolio that reflects NOS commitments to marine transportation and coastal environmental stewardship issues. Of these, 19 meet (to varying degrees) Ocean.US criteria to potentially serve as "national backbone" elements – i.e., routine and sustained measurements of core variables with broad spatial distribution and fairly robust data management systems. Two programs, in their current form, represent mature components of the national backbone – the National Water Level Observation Network (NWLON) and the Continually Operating Reference System (CORS). Seventeen others could meet national backbone criteria by enhancing their spatial extent and/or temporal sampling frequency or expanding data delivery capabilities.

SELECTED RECOMMENDATIONS

Selected recommendations to enhance NOS observing systems and better integrate them within the IOOS framework include:

- Re-evaluate monitoring requirements in the context of agency mandates
- Conduct a detailed, comprehensive "use and users" assessment
- Develop a "spatial data portal" for NOS' operational monitoring data
- Assemble a small, full-time team to assist NOS programs with next step activities
- Identify, design and test targeted "demonstration projects"
- Adopt and help develop technologies and metadata standards
- Participate in the development of national standards for biological monitoring

Center for Operational Oceanographic Products and Services (CO-OPS)
- National Current Observation Program
- National Water Level Observation Network
- Physical Oceanographic Real-Time Systems

Coastal Services Center
- Benthic Habitat Mapping
- Coastal Change Analysis Program
- Topographic Mapping

National Centers for Coastal Ocean Science
- National Status and Trends
  - Benthic Surveillance
  - Mussel Watch
  - Bioeffects Assessments
- Coral Reef Mapping
- Coral Reef Monitoring
- Harmful Algal Bloom Monitoring

National Geodetic Survey
- Coastal Mapping Program
- Continuously Operating Reference Stations
- National Spatial Reference System

Office of Coastal Survey
- Hydrographic Surveying

Office of Coastal Resource Management
- National Estuarine Research Reserve System

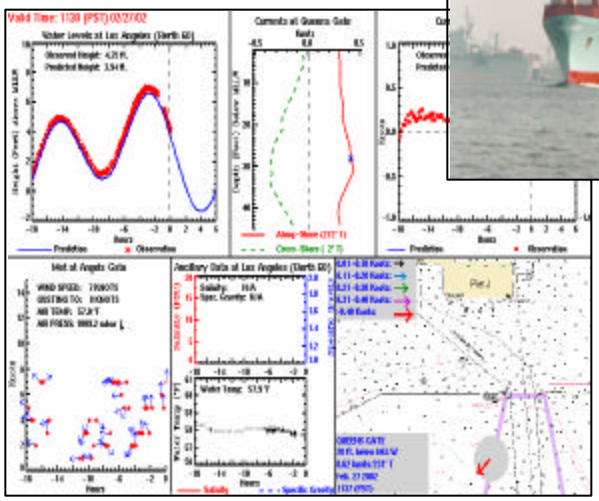
Office of National Marine Sanctuaries
- National Marine Sanctuary System

Office of Response and Restoration
- Environmental Sensitivity Index Mapping

NOS Operational Observing Systems with potential as components of a "national backbone."

1 INTRODUCTION

This report describes the potential contributions that the NOAA Ocean Service (NOS) can make to the development of an Integrated Ocean Observing System (IOOS). The IOOS, a concept developed over the past decade by national government, academic research and international organizations, is envisioned as a network of linked and coordinated monitoring/observation programs, associated data management and delivery activities, and supported models and applications that will provide a basic set of oceanographic and environmental data and predictions to the coastal research and management communities.



NOS has a long history of designing and operating sustained coastal observing systems that provide a suite of applied data products supporting marine transportation and coastal resource management.

The IOOS has been proposed to address perceived deficiencies in the current monitoring activities conducted by federal, state and local government and research organizations. These deficiencies include spatial and temporal gaps in coverage, lack of coordination among programs, differences in data formats, and a variety of data delivery mechanisms. A successful implementation of IOOS will produce a systematic and consistent set of observations supporting national, regional and local priorities that will result in more effective and sustainable management and utilization of the marine environment and its natural resources (see NORLC, 1999 and C-GOOS Steering Committee, 1999).

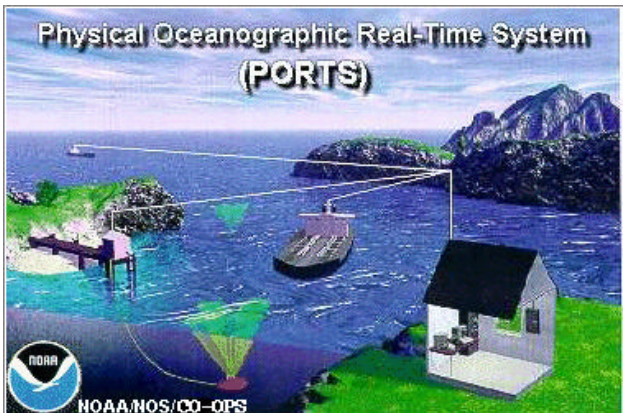
Because the IOOS goals intersect with NOAA's mission to observe and predict environmental changes, protect life and property, provide decision makers with reliable scientific information, and foster global environmental stewardship, NOAA has an opportunity to provide significant leadership in implementing the system. NOS, as the principal advocate in NOAA for coastal and ocean stewardship and the generator of a wide array of oceanographic and environmental measurements, can play a major role in this implementation for a number of IOOS components.

1.1 DEFINITIONS -- Operational Observing Systems, Coastal Monitoring, and National Backbone

Three terms (section 1.1) were particularly important in determining the focus of the evaluation, and warrant definition and discussion in this introduction.

OPERATIONAL OBSERVING SYSTEMS. The directive limited the assessment to operational observing/monitoring systems. The European Global Ocean Observing System (GOOS) report provides this guidance: "Operational Oceanography can be defined as the activity of systematic and long-term routine measurements of the seas and oceans and atmosphere, and their rapid interpretation and dissemination. Operational oceanography is proceeded usually, but not always, by the rapid transmission of observational data to data assimilation centers. There, powerful computers are used to generate data products, often through intermediary value-adding organizations. Examples of final products include warnings (of coastal floods, ice and storm damage, harmful algal blooms, and contaminants), electronic charts, optimum routes for ships, prediction of seasonal or annual primary productivity, ocean currents and ocean climate variability. The final products and forecasts must be distributed rapidly to industrial users, government agencies, and regulatory authorities."

The assessment team used this guidance to limit the NOS observing systems considered in the analysis to those that took "systematic and long-term routine measurements". This eliminated a number of research observing activities that are typically short term and more site specific.



PORTS is an example of a "national backbone" component, providing an "end-to-end" capability that includes observation, data delivery, and models/forecasts.

COASTAL MONITORING. The spatial focus of the assessment was limited to coastal monitoring. This was taken to include the estuarine, near coastal, and off shore waters seaward to the continental shelf break, and coastal land areas draining to these waters. Monitoring of land-based parameters was included because it is essential to support NOS coastal management and response and restoration responsibilities.

NATIONAL BACKBONE. A third important directive in the charge was to focus on NOS' contribution to a national coastal observing backbone. This backbone should have some important attributes to be successful, including:

1) ***Support Federal missions and mandates***. The systems should provide for meeting the formal programmatic needs of the Agency's missions in serving their national users.

2) ***Have the characteristics of an operational observing system.*** Along with providing a reference network, the system should have "sentinel" characteristics with the ability to provide early warning indicators and long term trends and adaptive monitoring capabilities.

3) ***Be national in scope.*** The systems should have network characteristics with observation locations throughout the coastal zone at a density appropriate to provide a national "picture" of the status and trends of parameters of interest.

4) ***Have an operational data communications and management sub-system and have the characteristics of an end-to-end observation to product system.*** The system should ensure that products are developed to address national and regional goals and that products are readily available to the public and other users. The system should enable the development of data assimilation techniques and predictive models.

5) ***Provide for a National framework into which a federation of regional observing systems is nested.*** A National Framework should provide for the establishment and sharing of protocols and standards for measurement and data exchange. The framework should allow for comparative analyses among regions and technology transfer and capacity building in the regions.

6) ***Provide information that allows for a National characterization or assessment of phenomena of interest.*** The backbone should be a reference network of observation locations that provide baseline and trend data required for basic knowledge, national assessment, and national policy formulation.

1.2 REPORT CONTEXT

In evaluating the information and recommendations presented in this report, it is important to recognize the context of actions and events that have transpired since the assessment was started in August 2001. The original intent was to provide the report as background for an OCEAN.US sponsored national workshop held in March 2002 at Airlie House, Virginia. The purpose of this workshop was to design the coastal component of IOOS– a major component of the workshop was to synthesize the capabilities that exist among the participants, including the types of observing systems and delivery mechanisms captured by the NOS inventory.

Scientists retrieve a Tucker net to sample different depths and obtain discrete samples of tiny organisms in the Cordell Bank Sanctuary.

At the same time, four other significant actions emerged that affected how this report could be used, and therefore, its contents and the timing of its completion. First, NOAA Administrator VADM Conrad Lautenbacher (US Navy Ret.) has expressed his strong support for NOAA's involvement in IOOS. To expedite this support, he convened a senior policy group called the NOAA Coastal Observation Steering Committee, chaired by NOS Acting Assistant Administrator Margaret Davidson, and requested that a NOAA-level plan for implementing a coastal observing system be completed by December 2002. Second, VADM Lautenbacher released the results of the NOAA Program Review in June, 2002. Recommendation 33 addresses the need to base the design of all future observing systems on a systematic requirements analysis, and suggests consolidating ocean observing systems within NOAA. Third, a briefing to the NOS Senior Management Council (May 2002) highlighted the findings of the inventory, solicited recommendations, and established a NOS-wide working group to implement priority activities. Among the highest priorities is the design of a web-based portal to provide a "one-stop" access point for distributing NOS observing/monitoring data. This fourth activity was initiated in June 2002, through a NOS Partnership Proposal to develop an Enterprise GIS for NOS spatial data.

The implications of actions initiated during the Spring and Summer of 2002 has been to delay the completion of this report to better target how the existing inventory and subsequent activities can support priorities set forward by VADM Lautenbacher, contribute to the coastal component of IOOS, and support NOS efforts to enhance its observing systems to meet program mandates. As a result, some of the recommendations presented in this report have already been initiated, while others continue to be evaluated for possible implementation.

1.3 REPORT ORGANIZATION

The report is presented in three major sections.

- **Chapter 1** describes the need and context for the report, including references to Ocean.US and definitions of key terminology.

- **Chapter 2** summarizes NOS' observational systems, including the existing capability to make coastal/ocean observations, deliver information through web sites and other mechanisms, and apply data through modeling and forecasting products.

- **Chapter 3** examines the monitoring assets inventory within the context of IOOS – specifically, to what extent can the NOS systems serve as components of the "national backbone" of a coastal/ocean observing network. IOOS identified several thematic targets, called "phenomena of interest" and the core variables that should be considered as part of the observing network – many of which align well with NOS functions.

2 NOS CAPABILITIES

This section summarizes NOS' operational observing systems and related data delivery methods and modeling/forecasting products. Together, these three elements represent an "end-to-end" suite of services consistent with IOOS and national backbone concepts. A survey conducted with NOS program offices focused primarily on characteristics of the observing systems – considerably less rigor was associated with defining similar characteristics for the data delivery and modeling/forecasting components. This work updates and expands a previous survey conducted in 2000.

2.1 BUILDING THE OBSERVING SYSTEM INVENTORY

In Spring 2002, NOS program offices were asked to describe and quantify characteristics of their coastal and ocean observing systems (Appendix 1). This survey included program descriptions, parameters measured, observing platforms, spatial and temporal scales, period of record, customers, modeling/forecasting products, data management system, metadata and FGDC compliance, and program funding. The latter (funding) was most difficult to define and therefore data were collected inconsistently.

The survey initially cast a wide net to capture the full range of measurements collected by NOS to support its diverse marine transportation and environmental mandates. All information collected was preserved in a digital database available through NOS Special Projects.

2.2 KEY FINDINGS - OBSERVING SYSTEMS

NOS directly supports 28 coastal ocean observing systems. Table 1 lists the observing systems submitted by NOS offices.

NOS programs gather physical, chemical and biological data (Table 1). Measurements occur throughout a range of spatial and temporal scales, and use a variety of measuring devices and technical approaches, ranging from remotely sensed data to synoptic sampling to continuous real-time monitoring. For some physical parameters, measurement approaches are well standardized (e.g., temperature and salinity) while for others (e.g., some chemical or biological monitoring), measurement methods are not as well developed or collection techniques may vary among NOS programs.

Survey of the Coast Act (1807)
Coastal & Geodetic Survey Act (1947)
Outer Continental Shelf Lands Act (1953)
Coastal Zone Management Act (1972)
Marine Mammal Protection Act (1972)
Marine Protection, Research and Sanctuaries Act (1972)
Endangered Species Act (1973)
Clean Water Act (1977)
Comprehensive Environmental Response, Compensation and Liability Act (1980)
Oil Pollution Act (1990)
National Coastal Monitoring Act (1992)
Coral Reef Task Force (1998)
Water Resources Development Act (1999)

A variety of authorizations direct NOS to operate coastal observing systems. Many of these are shared responsibilities with other NOAA offices and Federal agencies. For more details on the specific authorizations for environmental monitoring contained in these laws, see CEMC, 2000.

The National Marine Sanctuary program is somewhat unique among NOS observing systems in that much of the monitoring within sanctuaries is derived through a variety of partnership efforts that address issues specific to each site. To best represent this range of monitoring, Table 1 lists the parameters measured at the sites, but only a subset are measured at any single site and none are measured at all sites.

Table 1. Parameters Measured by NOS Observing Systems

Program Name	NOS Office	Surface Wind	Barometric Pressure	Air Temperature	Precipitation	Sea Level/Water Level	Bathymetry	Coastal Geomorphology	Sea Surface Temperature	Subsurface Temperature	Salinity	Surface and Subsurface Currents	Current Profiles	Turbidity/Total Suspended Solids	Bottom Sediment Type	Bottom Sediment Grain Size	Nitrogen	Phosphorus	Dissolved Oxygen
National Current Observation Program (NCOP)	CO-OPS									X		X	X						
National Water Level Observation Network (NWLON)	CO-OPS	X	X	X		X			X		X								
Physical Oceanographic Real-Time Systems (PORTS)	CO-OPS	X	X	X		X			X		X	X							
Benthic Habitat Mapping Project	CSC							X							X	X			X
Land Cover Change Analysis - Coastal Change Analysis Program (C-CAP)	CSC							X											
Topographic Mapping (using LIDAR sensors)	CSC							X											
National Status and Trends - Benthic Surveillance	NCCOS														X	X			
National Status and Trends - Mussel Watch	NCCOS														X	X			
National Status and Trends - Bioeffects Survey	NCCOS						X		X	X	X				X	X			
Coral Reef Mapping	NCCOS						X								X				
Coral Reef Monitoring	NCCOS			X					X	X	X			X	X		X	X	X
Harmful Algal Bloom Monitoring	NCCOS																		
Coastal Mapping Program	NGS																		
Continuously Operating Reference Stations (CORS)	NGS		X	X		X													
National Spatial Reference System (NSRS)	NGS		X	X		X													
Hydrographic Surveying	OCS						X								X	X			
National Estuarine Research Reserve System-wide Monitoring Program (NERRS)	OCRM	X	X	X	X	X			X		X			X			X	X	X
National Marine Sanctuary Program Summary	ONMS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Channel Islands NMS	*ONMS*						X		X	X	X			X	X	X			
Cordell Bank NMS	*ONMS*	X	X	X	X				X		X		X						
Fagatele Bay NMS	*ONMS*						X			X	X			X					X
Florida Keys NMS	*ONMS*	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Flower Garden Banks NMS	*ONMS*	X	X	X		X	X		X	X	X	X	X	X	X	X			X
Grays Reef NMS	*ONMS*	X	X	X					X										
Monitor NMS	*ONMS*	X					X					X	X	X	X				
Monterey Bay NMS	*ONMS*	X	X	X			X	X	X	X	X	X	X	X	X	X	X	X	X
Olympic Coast NMS	*ONMS*	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
Stellwagon Bank NMS	*ONMS*	X		X			X		X	X	X	X		X	X	X	X	X	X
Environmental Sensitivity Index Mapping	OR&R							X											

Table 1 (cont'd). Parameters Measured by NOS Observing Systems

Program Name	NOS Office	Silicon	Other Inorganic Consituents	Chemical Contaminants	Freshwater Discharges	Sediment Discharge Load	Chlorophyll-a, Phytoplankton Pigments and/or Ocean Color	Attenuation of Photosynthetically Active Radiation	Harmful Algal Blooms	Coastal Marsh Elevation Topography and Changes	Shoreline Topography and Changes	Habitat Extent and Change	Nonindigenous Species Presence and Abundance	Coastal Landuse Patterns	Storm Surge	Oil or Chemical Spills	Vertical and Horizontal Datums	Other Parameter
National Current Observation Program - NCOP	CO-OPS																	
National Water Level Observation Network - NWLON	CO-OPS													X		X		
Physical Oceanographic Real-Time Systems - PORTS	CO-OPS													X		X		
Benthic Habitat Mapping Project	CSC					X												
Land Cover Change Analysis - Coastal Change Analysis Program C-CAP	CSC										X	X		X				
Topographic Mapping - using LIDAR sensors	CSC									X								
National Status and Trends - Mussel Watch	NCCOS			X											X			
National Status and Trends - Benthic Surveillance	NCCOS			X														X
National Status and Trends - Bioeffects Survey	NCCOS			X														X
Coral Reef Mapping	NCCOS																	
Coral Reef Monitoring	NCCOS			X		X	X	X				X						
Harmful Algal Bloom Monitoring	NCCOS																	X
Coastal Mapping Program	NGS										X							
Continuously Operating Reference Stations - CORS	NGS									X	X						X	
National Spatial Reference System - NSRS	NGS									X	X						X	
Hydrographic Surveying	OCS											X					X	
National Estuarine Research Reserve System-wide Monitoring Program (NERRS)	OCRM						X	X										
National Marine Sanctuary Program Summary	ONMS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Channel Islands NMS	*ONMS*														X			
Cordell Bank NMS	*ONMS*																	X
Fagatele Bay NMS	*ONMS*																	
Florida Keys NMS	*ONMS*	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	
Flower Garden Banks NMS	*ONMS*			X														X
Grays Reef NMS	*ONMS*																	
Monitor NMS	*ONMS*																	
Monterey Bay NMS	*ONMS*	X	X	X	X	X	X	X	X	X	X							
Olympic Coast NMS	*ONMS*			X		X			X		X	X	X			X	X	
Stellwagon Bank NMS	*ONMS*	X			X		X					X						
Environmental Sensitivity Index Mapping	OR&R											X						

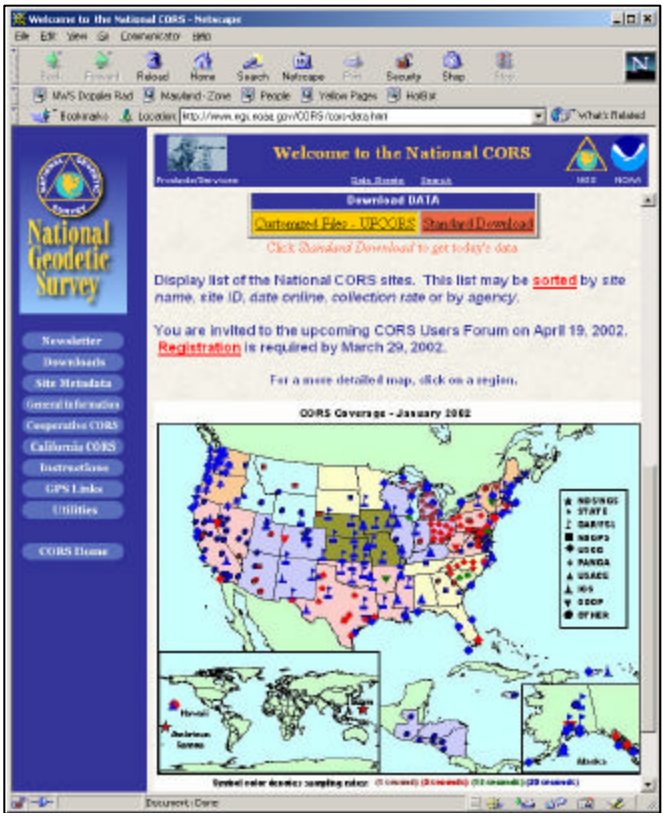
Of the 28 programs listed in the NOS inventory, 19 are considered to be "operational". These programs are routine, sustained, and have a broad enough spatial distribution to be considered candidates for a national backbone, i.e., they meet the criteria for the national backbone as presented in Section 3. Nine programs did not meet these criteria because they were either very site specific or because they were not true observation programs (e.g., they represented modeling capabilities, processed data products, etc). Consequently, these nine were dropped from subsequent data collection and assessments related to IOOS (Section 3).

NCCOS	Everglades Restoration
NCCOS	Fisheries Oceanography and Ecology
NCCOS	Hypoxia Hydrographic & Biological Surveys
NCCOS	Poplar Island Restoration
NCCOS	South Florida Benthic Community Monitoring
NCCOS	Tortugas Ecosystem
OCS	Marine Modeling
OR&R	Oil Spill Response
OR&R	Watershed Database & Mapping Project

Nine NOS programs not considered "operational" for the purposes of contributing to a "national backbone."

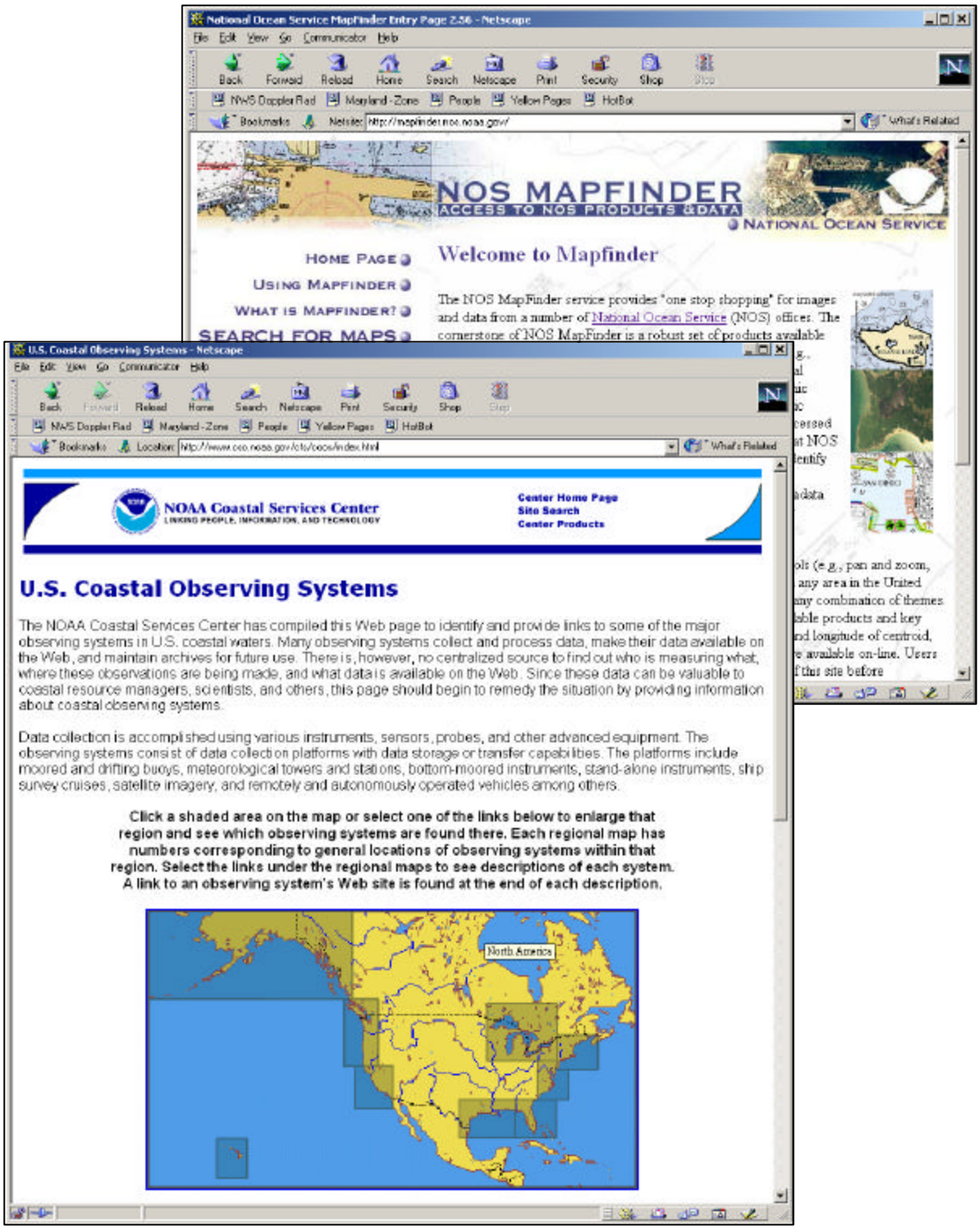
2.3 KEY FINDINGS - DATA DELIVERY SYSTEMS

NOS programs deliver data, information and products through a variety of media, including web sites, CD-ROMs, paper reports, automated telephone messages, radio and television public service announcements. Much of the data are available through web sites which offer users a range of access tools including data downloads, query functions, on-line mapping capabilities, and training materials. NOS sites typically make good use of graphics and images and they provide explanations regarding the data and their use. However, these sites are not integrated and do not have standard formats, presentations and links to common data sets and information types. The NOS Mapfinder service provides a strong beginning for an integrated "one stop shop" of NOS coastal data and products, but much more effort is required to establish a complete service.



NOS' web site for the Continuously Operating Reference System (CORS) includes interactive mapping, data downloads, comparative analyses, and metadata records.

The survey produced an extensive but preliminary, data table that describes the data management and delivery system for each NOS observing program. Parameters include program name, period of record, data archive location, Federal Geographic Data Committee (FGDC) compliance, time to deliver observations, and other comments. This information requires additional refinement and review, but is maintained in digital form by NOS Special Projects Office.



NOS MapFinder and CSC's Coastal Observing Systems' websites are examples of internet "portals" to data and imagery across several NOS programs. Users can query, map and download data products. NOS has initiated an effort under its NOS Enterprise GIS initiative, based on these two websites, to develop an internet spatial data portal for all NOS operational observing systems and digital geographies. This portal site is expected to enhance public access to NOS information and provide users with additional (and easy to use) web-based tools for mapping, downloading, and merging data sets.

2.4 KEY FINDINGS - MODELING / FORECAST SYSTEMS

The integration of operational models with observing systems is a primary design feature of IOOS and the third component of an "end-to-end" capability. Modeling and forecasting systems were not explicitly inventoried at the same time as the observational programs and their data delivery systems. Instead, NOS program offices completed an assessment of these capabilities as part of a Homeland Security exercise in November 2001.

NOS currently supports 14 numerical hydrodynamic models, some of which have the potential for providing input to water quality and sediment transport needs. Most of these are associated with the Coast Survey Development Lab (CSDL), HAZMAT and CO-OPS programs (Table 2). Their operational requirements are driven primarily by the navigation and port operation communities, although forecast outputs are becoming increasingly important for environmental applications. Some NOS models (e.g., PORTS) are run on a 24/7 basis, providing real-time forecasts via the web and other distribution mechanisms. Other models (e.g., oil spill response) do not run in a continuous 24/7 mode, but can be deployed within two hours at nearly all coastal locations. Most models target specific locations, such as harbors or discrete areas of estuaries and coastal waters. NCCOS' Harmful Algal Bloom forecast bulletin, for example, uses satellite imagery to detect blooms along the west Florida shelf.

NOS Program	Location of Modeled Area	Model Name	Description
*CSDL/CO-OPS	Chesapeake Bay	MECCA, CBOFS	Chesapeake Bay Operational Forecast System - Nowcast & forecast water levels
CSDL	Chesapeake Bay	QUODDY	Nowcast & forecast water levels, currents, temperatures, salinity
CSDL	Chesapeake Bay	CH3D	Nowcast of water levels, currents, temperatures, salinity; sea nettle nowcasts
*CSDL/CO-OPS	NY/NJ Harbor	POM	Nowcast & forecast water levels and currents
CSDL	Galveston Bay	POM	Nowcast & forecast water levels, currents, temperatures, salinity
CSDL	Chesapeake Bay Region	LAPS	Atmospheric analysis and forecasts
CSDL	Narragansett Bay Region	LAPS	Atmospheric analysis and forecasts
CSDL	Various	POM, ELCIRC, ADCIRC	Tidal modeling for V-Datum
CSDL	Tampa, LS, NY, DE, CA	TCARI	Tidal modeling for bathy/topo
CSDL	St. John's River	EFDC, ELCIRC	Nowcast & forecast water levels, currents, temperatures, salinity for storm surge
CSDL/NCCOS	West Florida Shelf	ROMS	Harmful Algal Blooms
*ORR HAZMAT	Anywhere - 25 major ports preconfigured	CATS	Three sub-models packaged to define circulation
*ORR HAZMAT	Anywhere - 25 major ports preconfigured	GNOME	2D steady state oil spill trajectory analyses
ORR HAZMAT	Anywhere - 5 major ports preconfigured	TAP	Statistical program for shoreline risk analyses

Table 2. NOS' Hydrodynamic Models. (*) Indicates operational models, others are experimental. The information in this table was compiled as part of an assessment of NOS capabilities to support Homeland Security.

2.5 RECOMMENDATIONS - NOS OBSERVING SYSTEMS

- Re-evaluate monitoring requirement in the context of agency mandates
- Conduct a detailed, comprehensive "use and users" assessment
- Conduct a detailed requirements analysis for observations, delivery and modeling
- Develop a "spatial data portal" for NOS' operational monitoring data
- Develop a system-wide monitoring plan for the National Marine Sanctuaries
- Assemble a small, full-time team to assist NOS programs with next step activities

Key recommendations to enhance NOS' operational monitoring and data delivery systems.

The following recommendations focus on ways to improve and expand NOS' operational observing systems. Several of these have been initiated while others could begin within the next 12 months. Many of these suggestions were presented to NOS senior managers in June 2002.

1) Initiate a more detailed and comprehensive requirements analysis to determine the tasks and priorities for enhancing and integrating NOS monitoring and data delivery capabilities. This analysis should include a "use and users" assessment to quantify primary and secondary users, user information, e.g. data, products and service needs in line with NOS program mandates, and the current satisfaction with NOS data delivery services. The analysis should include an assessment of the unit and total cost of enhancing the observing network, data delivery, and products developed. NOS may be able to use an existing OMB approved questionnaire for this task. Similar analyses will later need to be performed for NOS modeling and research activities.

2) Develop an NOS Spatial Data Portal to provide "one-stop shopping" for key NOS operational monitoring program data. One of the key components of this portal site will be a searchable index or catalog of NOS monitoring programs and parameters. This feature will allow users to query the contents of the data portal by key words, and receive a result indicating all programs providing information for that keyword. The user will then identify the data source(s) of greatest value and be able to retrieve the monitoring site location information and the associated monitoring data. NOS should plan to display these data within an interactive web-based GIS. The coastal monitoring inventory developed to support this analysis will form the basis for this index, but will need to be enhanced with additional metadata information from all NOS offices. Planning for this project has began and a team comprised of multiple program offices has formed.

3) Target a percentage of NOS Partnership Proposal funding to apply to projects which promote or advance the integration of NOS coastal data with other NOAA partners to improve the ability of NOAA to meet one or more of its mandates. An advisory group familiar with data integration principles, and in particular, IOOS data integration goals and related IOOS/GOOS data integration activities would review these proposals. The approved proposals would focus on developing procedures, standards and protocols to facilitate the exchange of data from multiple NOAA line organizations, along with integration of data to create enhanced products targeted to one or more NOAA mandates.

4) Form a small core working team that focuses full time on integrating NOS monitoring according to IOOS principles, with sub-teams to address relevant modeling and research efforts. This monitoring integration team should include individuals that are familiar with the scope of NOS monitoring, product processing and analysis, have technical capabilities to build a more comprehensive inventory of operational NOS monitoring programs, can and assist in developing a web-based data delivery portal. This team would work closely with an advisory group comprised of representatives from each NOS program and staff office having an operational monitoring program, and if possible, with selected users.

program and staff office having an operational monitoring program, and if possible, with selected users. Likewise the sub-teams for modeling and research would have members familiar with coastal modeling and research challenges, needs and future directions. This activity has been initiated with funds from a NOS Partnership Proposal.

5) Develop a monitoring plan for the NOAA National Marine Sanctuaries and ensure that it is coordinated with other relevant monitoring programs at the federal and regional level. This is underway and is being supported by a team of national experts who are providing input relative to the monitoring strategy, report products and integration opportunities.

3 CONTRIBUTIONS to IOOS and OCEAN.US

A workshop sponsored by Ocean.US in March 2002 provided an important target and application for the NOS inventory. Ocean.US is promoting the US component of the "integrated and sustained ocean observing system (IOOS) which is being designed and implemented in accordance with the principles of the international Global Ocean Observing System. This section focuses on the coastal component of IOOS and evaluates the potential for NOS to contribute to a national framework of operational observing systems.

3.1 DEFINING IOOS and OCEAN.US

IOOS is a concept developed over the past decade by national governments, academic research and international organizations to enable effective and sustainable management and utilization of the marine environment and its natural resources (http://ocean.us.net or http://ioc.unesco.org/goos). Due to the complexity of coastal issues as well as the number and variety of agencies, groups and users involved in monitoring and prediction, it has become increasingly important to develop an integrated, multi-disciplinary and sustained observing system. The goal is to improve the resolution of observations in time and space, expand the variables measured, target modeling and research capacity, and improve data management and delivery to meet user needs.

To help set an initial target for design and implementation, IOOS has called for the development of a national network of observing systems -- termed the "national backbone" -- that will satisfy the most

Marine Services, Natural Hazards, National Security
- Sea level
- Sea state
- Coastal circulation
- Coastal flooding
- Shoreline changes
- Changes in shallow water bathymetry

Public Health
- Seafood contamination
- Abundance of pathogens

Ecosystem Health
- Habitat modification and loss
- Biodiversity
- Eutrophication
- Harmful algal events
- Invasive species
- Disease & mass mortality of marine organisms

Living Resources
- Changes in abundance of exploitable LMRs
- Change in landings (plants and animals)

Table 3. IOOS phenomena of interest

Meteorological
- Surface wind
- Air pressure & temperature
- Precipitation

Physical
- Sea level
- Bathymetry & geomorphology
- Temperature
- Salinity
- Surface currents
- Surface waves
- Turbidity & total suspended solids
- Sediment type & grain size

Chemical
- Dissolved nutrients (nitrogen, Phosphorus, silicon)
- Dissolved oxygen

Biological
- Chlorophyll-a
- Phytoplankton pigments & ocean color
- Species composition (including HABs and non-indigenous species)
- Attenuation of Photosynthetically Active Radiation

Table 4. IOOS core variables

common requirements for data acquisition and management among national agencies and partners. As a starting point, IOOS identified several broad coastal issues (termed "phenomena of interest") that would be optimally served by the development of an integrated (i.e., multi-disciplinary and end-to-end) and sustained ocean observing system (Table 3). In addition, a list of "core variables" (Table 4) was promoted by IOOS as those having broad application across a range of coastal and ocean issues. These do not necessarily relate directly to the phenomena of interest.

The NOS inventory provided input to a national workshop to define the national backbone, its core variables, and implementation strategies. For more information on Ocean.US, visit www.ocean.us.net

In March 2002, Ocean.US sponsored a national workshop to design the coastal component of IOOS, based on the framework identified above. To help NOS determine its potential contribution to the national backbone, its inventory of coastal/ocean observing systems, data delivery capabilities and model/forecast functions was evaluated and rated against the phenomena of interest and the core variables.

3.2 APPROACH

Observing Systems. NOS' 19 operational observing systems were reviewed in terms of their potential contribution as a "national backbone" element. Specifically, they were evaluated against their ability to monitor and/or predict the IOOS phenomena of interest (Table 5) and their ability to provide continuous and routine measurements of IOOS core variables (Table 6). Programs were scored using a scale of 1 to 5, with the following definitions:

5 - ready as is/comprehensive
4 - operational but could be expanded or enhanced
3 - some capability/needs work
2 - basic potential to provide data
1 - no or minimal capability

Data Delivery. The 19 programs (and their product lines) were also evaluated for their data and information management capabilities, including whether digital data were available on NOS web pages, whether data and metadata are FGDC-compliant, the time between data acquisition and data delivery, and product types. Considerations also included the ease of locating and obtaining real-time, near real-time and historical data; the availability of tools and products to allow easier use of the data; the ease of locating related data and products; and the availability of information about how the data could be applied to applications other than the primary mission. Given these, delivery systems were subjectively evaluated for their application to assessing or forecasting each IOOS phenomenon of interest (Table 7). The data management and delivery programs were rated as a national backbone component using the following criteria:

5 - programs are contributing fully to the understanding of relevant phenomena of interest
4 - significant contribution is in place in NOS, but could be enhanced or expanded
3 - some existing contribution in NOS, but needs significant work to complete
2 - some basic potential exists in the present NOS programs
1 - no present contribution nor active plans to contribute exists within NOS

Modeling/Forecasting. The assessment of NOS modeling capabilities was limited to the inventory developed as part of the November 2001 Homeland Security survey (Table 2). No attempt was made to evaluate these capabilities within the context of IOOS phenomena of interest or core variables.

3.3 KEY FINDINGS

Ratings provided below reflect NOS' overall capability to contribute to the phenomenon of interest and core variables on a national scale. To the extent possible, specific program names are listed that provide the bulk of NOS' capacity for any given rating.

Evaluation against IOOS Phenomena of Interest

Marine Services, Natural hazards, National Security	
4.5	Sea level
1	Sea state
3	Coastal circulation
3.5	Coastal Flooding
3	Shoreline changes
2.5	Changes in shallow water bathymetry
Public Health	
2	Seafood contamination
2	Abundance of pathogens
Ecosystem Health	
3	Habitat modification and loss
2	Biodiversity
2	Eutrophication
3.5	Harmful algal events
2	Invasive species
3	Disease and mass mortality of marine organisms
Living Resources	
1	Changes in abundance of exploitable LMR's
1	Changes in landings (plants and animals)

Table 5. Rating the potential for NOS' operational observing systems to contribute to the IOOS Phenomena of Interest – The score reflects the highest rating received by any NOS program

The ability of NOS programs to support sea level measurement was rated highest (rating 4.5) due to the national scope of CO-OPS's NWLON and PORTS programs as well as NGS's CORS and NSRS programs. These programs collect real-time water level information in support of marine operations and natural hazards.

NOS has significant ability (rating 3.5) to evaluate coastal flooding through NWLON and PORTS and their linkages to the National Weather Service storm surge and marine forecasting systems. NGS and CSC's Remote Sensing Program have the potential to support coastal flooding evaluations through digital elevation mapping and shoreline mapping activities.

Additionally, NOS has a demonstrated ability (rating 3.5) to contribute to assessments of harmful algal events through its Harmful Algal Bloom Monitoring Program and the Harmful Algal Bloom Forecast Bulletin (NCCOS and CSC).

Some expertise (rating 3.0) also exists to support these phenomena of interest: coastal circulation (through PORTS, NWLON and current programs); shoreline change (NGS remote sensing and shoreline mapping; CSC coastal change analysis and topographic mapping program; OR&R Environmental Sensitivity Index Maps; and NGS, CORS and NSRS projects); habitat modification (OR&R marsh restoration, NERRS, and CSC/NCCOS benthic habitat mapping and monitoring); disease and mass mortality (NCCOS Status & Trends).

Through the Hydrographic Survey programs and new LIDAR mapping, NOS contributes (rating 2.5) to the understanding of changes in shallow water bathymetry.

Minimal contribution, but with potential (rating 2.0) exists for understanding seafood contamination, exposure to pathogens, changes in biodiversity, eutrophication and invasive species. Little to no capability exists (rating 1.0) for living resources characterization.

Evaluation against IOOS Core Variables

Evaluation of NOS programs against the IOOS core variables produced similar results to phenomena of interest comparisons. Physical measurements, especially those associated with direct support of NOS' marine transportation responsibilities, rated highest while water quality and biological parameters scored lower.

Observations of sea level were rated highest (rating 4.5) due to the national scope of NWLON and PORTS and the potential to densify the existing network through state partnerships. In contrast, NOS has little to no capacity (rating 1.0) to observe surface waves and precipitation and limited capacity (rating 2.0) for turbidity (suspended solids), water quality (e.g., dissolved oxygen, nutrients), PAR, and species composition.

Meteorological	
3	Surface wind
3	Air pressure & temperature
1	Precipitation
Physical	
4.5	Sea level
4	Bathymetry & geomorphology
3	Temperature
3	Salinity
3	Surface currents
1	Surface waves
2	Turbidity & total suspended solids
3	Sediment type & grain size
Chemical	
2	Dissolved nutrients (nitrogen, phosphorus, silicon)
2	Dissolved oxygen
Biological	
2	Chlorophyll-a
3	Phytoplankton pigments & ocean color
2	Species composition (including HABs and non-indigenous species)
2	Attenuation of PAR

Table 6. Rating the potential for NOS operational observing systems to contribute to the IOOS core variables – The score reflects the highest rating received by any NOS program.

Evaluation of Data Delivery Systems

The web sites of the 19 "operational" observing programs were subjectively evaluated against the rating criteria as a way of representing the range of functionality that currently exists. Each program was scored from 1-5, where 1 was lowest and 5 was highest (Table 7). It should be noted that NOS web site features and capabilities have continued to evolve and improve since the "snapshot" taken in November 2001. In particular, many new functional features have been added to the NCCOS' National Status and Trends Programs (i.e., Mussel Watch, Bioeffects, Benthic Surveillance). A more rigorous update of all NOS data delivery systems is required.

Nine programs scored 4 or more, indicating an "operational" capability exists. These sites contained many of the features of a robust data delivery site, including:

- Ease of navigation (minimum number of clicks to get to the data);
- Searchable by parameter, location or time period;
- Access to near real-time, archived data, and data of national scope;
- Visualization tools, such as maps, charts and tables;
- Metadata documentation, including how to use and interpret the data; and
- Download data in various formats.

Program Web sites	
4+ Highest	CO-OPS NWLON program OR&R Oil Spill Response Program CSC/NCCOS HAB Forecast Bulletins
4 to 4- Above Average	CO-OPS PORTS Program OR&R ESI Mapping Program NGS CORS and NSRS Programs CSC Topographic Mapping CSC C-CAP Program CSC Benthic Habitat Mapping Program
3+ to 3- Average	OCRM NERRS Program OCS Nautical Charting Program NCCOS Mussel Watch Project* NCCOS Benthic Surveillance Project*
2+ to 2- Below Average	NCCOS Coral Reef Mapping Program NGS Coastal Mapping Program NCCOS Bioeffects Project*
1 Lowest	NMS Program

Table 7. Subjective rating of web site capability to serve NOS observation data - this rating only reflects data delivery -- it does not address other aspects of these web sites. The (*) indicates significant enhancements to the NCCOS web site functions since the initial ratings in November 2001.

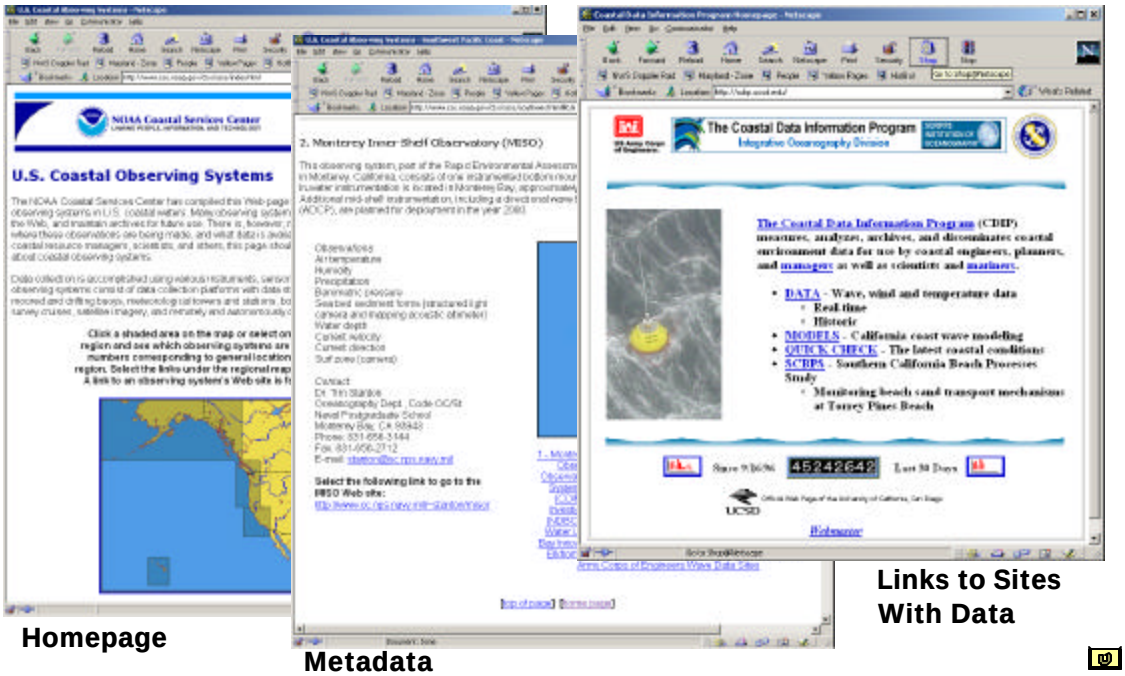
Figures 1 and 2 illustrate some of NOS' web site functions – many are consistent with delivery and features described by the IOOS community. NOS supports two sites that serve as data portals – Mapfinder (NOS) and US Coastal Observing Systems (CSC). In addition, CO-OPS provides real time access and visualization of water level data, while NCCOS offers interactive mapping and time series visualizations of environmental quality data for the three primary National Status and Trends projects. A variety of similar capabilities exist among several other NOS sites.

Systems such as NWLON, PORTS, CORS and oil spill response scored higher because data were easy to find and download, the site provided a variety of tools to assist users, and the user had access to a range of products.

Overall, NOS websites provide access to many IOOS core variables, an abundance of tools, aids and training materials. Sites also make good use of maps, graphics and images. Areas to improve include access to related NOS data or programs, access to raw data for derived products, and data availability in GIS formats.

Portal Sites / CSC's US Coastal Observing Systems

http://www.csc.noaa.gov/cts/coos/index.html



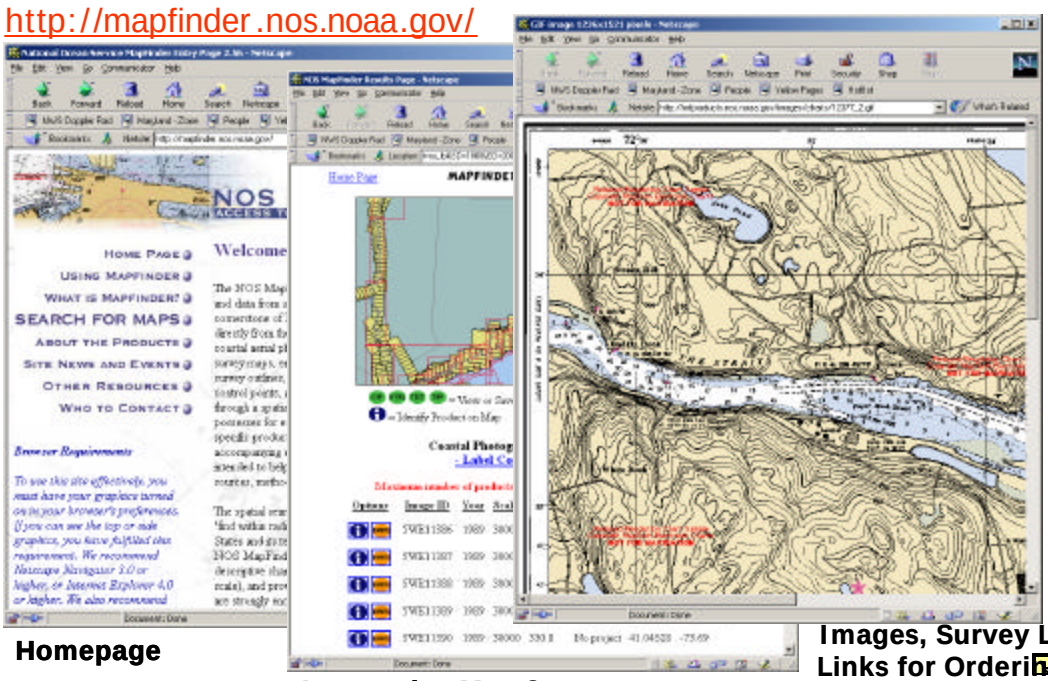
Homepage

Metadata

Links to Sites With Data

Portal Sites / MapFinder

http://mapfinder .nos.noaa.gov/



Homepage

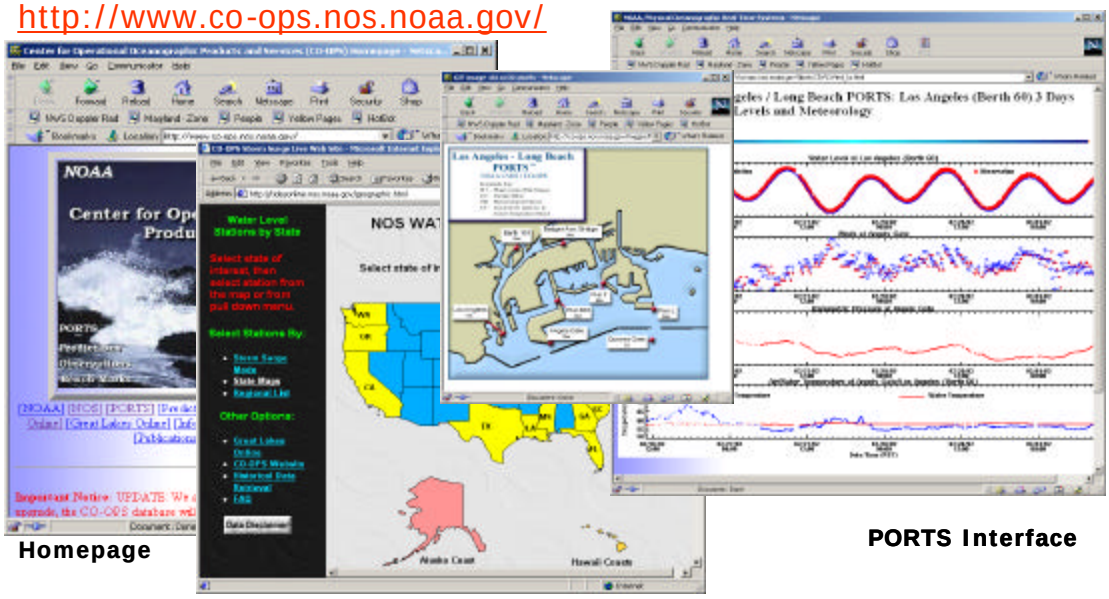
Interactive Map Server

Images, Survey Lines Links for Ordering

Figure 1: Example of NOS web sites that serve as portals to multiple data sets. Additionally, these sites have functions that include interactive map serving, metadata, images, and product ordering.

Near Real Time Ocean Conditions / CO-OPS

http://www.co-ops.nos.noaa.gov/



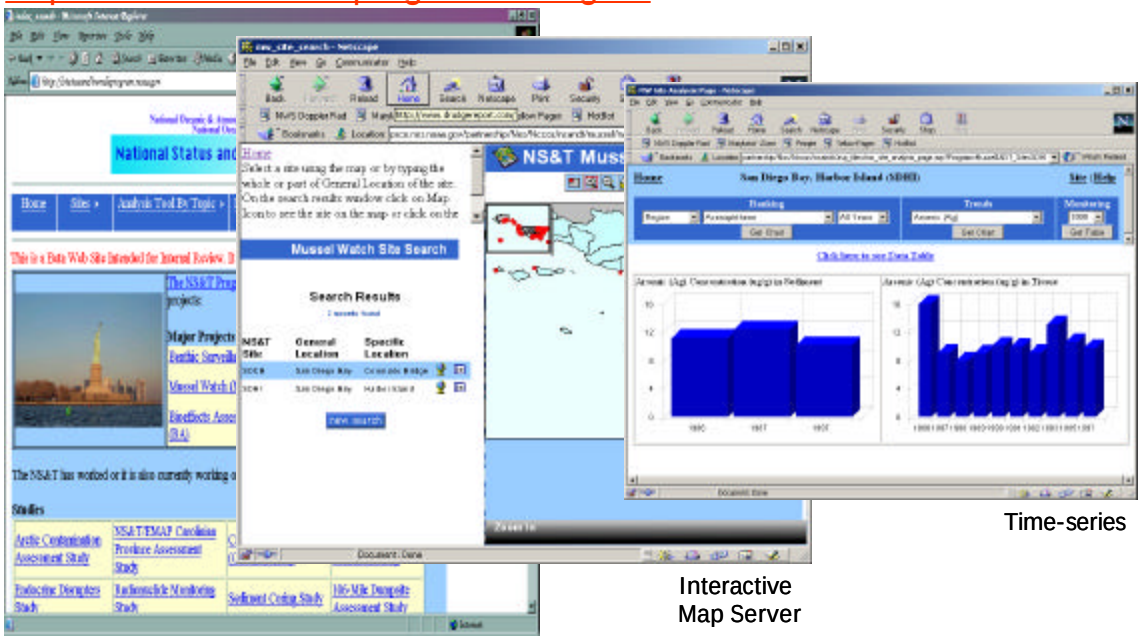
Homepage

Real-time Water Level Observations and Predictions

PORTS Interface

Environmental Quality / Status and Trends

http://statusandtrendsprogram.noaa.gov/



Homepage

Interactive Map Server

Time-series

Figure 2: Examples of NOS web sites with functions such as real-time data access, data visualizations, user-defined data summaries, and interactive search functions.

3.4 RECOMMENDATIONS

- Refine definition of "national backbone" and related capabilities
- Better associate NOS-IOOS connections within the context of NOS mandates and stewardship - Conduct a targeted requirements and gaps analysis
- Adopt and help develop technologies and meta data standards data
- Develop national standards for biological monitoring
- Increase efforts to develop a QA/QC component for the observing system
- Review modeling activities within context of agency mandates
- Identify, design and test targeted "demonstration projects"
- Increase efforts to gain public support to sustain NOS' observing systems
- Increase NOS participation on the NOAA Steering Committee on Coastal Ocean Observations

Key recommendations to improve and promote NOS systems for the "national backbone."

The following recommendations consider ways to improve and promote NOS' operational observing and delivery systems as part of the "national backbone" and/or other IOOS components. Several of these relate directly to the continued evaluation and expansion of NOS' observing programs as recommended in Chapter 2 as well as the implementation of the proposed NOS data portal. Many of the following ideas to better connect NOS to IOOS activities reflect the input of NOS senior managers.

1) Continue to work with Ocean.US and the IOOS community to refine the definition of the federal or national backbone. The definition should clearly distinguish observations, delivery, modeling and products.

2) Identify management questions, derived from existing mandates, for which the benefits of a national backbone and data delivery function can be determined. Questions could focus on a particular theme, e.g., climate change, providing the theme can be sufficiently narrowed and applied to NOS' priorities and stewardship responsibilities.

3) Based on (2), conduct a requirements and gaps analysis to better determine the NOS contribution (existing and projected) to the IOOS national backbone. This should include specific references to efficiencies, expansions, products, users, and performance measures. In addition, NOS should ensure coordination with other NOAA line offices and federal agencies to define niches and partnership opportunities.

4) NOS expertise in data management and data standards regarding monitoring and distributing of oceanographic information, collection of biological and chemical data, applications of oceanographic data and technology transfer could be considered as candidates for IOOS. Collaboration with and participation in ongoing governmental or NOAA projects such as FGDC standards for geospatial data, agency-wide ("enterprise") GIS, NESDIS' National Coastal Data Development Center's coastal database, and U.S. GOOS data management efforts would help focus NOS's expertise in this area.

5) In coordination with NMFS and other experts, develop a set of national standards for biological sampling of LMR. This team should also include EPA, USFWS and state partners who collectively have responsibility for public health and the health of LMR. Outcome of this work should help focus NOS programs involved in these areas.

6) Review NOS hydrodynamic and ecological modeling activities for relevance to NOS mandates, user satisfaction with products and delivery mechanisms, resources needed for ongoing research, operations

maintenance and incremental improvements; and identification of roles and responsibilities within NOS and project partners. The first area to review could be HAB models.

7) NOS should continue its participation on the new NOAA Steering Committee on Coastal Ocean Observations, and also increase its participation and focus on coastal observing activities by forming an internal working group composed of representatives from all offices. This committee would take on the responsibility of additional study, tasking and collaboration of approved action items.

8) Identify a discrete set of demonstration projects to be developed and tested, especially those directed at a specific IOOS theme. The range of projects considered should provide insights into monitoring technologies, communications, measurement schemes, dissemination of data streams, and uses to which they are applied. A geographic focus also may be useful. The pilots should also direct energies toward gaining broad-based public support to implement and sustain NOS monitoring investments.

4 LOOKING AHEAD

This report represents NOS' initial attempt to describe its programs within the context of a national IOOS framework. Over the course of its development, and even prior to its completion, its concepts and initial findings have served to increase awareness of NOS' existing observing infrastructure, both inside the line office and throughout NOAA. It has also served as a catalyst to re-evaluate the requirements, conditions, costs and benefits of an expanded observing system, especially one that has a clear niche within the larger federal and regional umbrella.

Since the commissioning of this report, much has changed throughout the agency that has bearing on how and why NOS carries out its monitoring activities. While new opportunities may have emerged, the targets are not yet clear and require more work to define. Even so, there remains a commitment from NOS program offices to grow their monitoring systems and better deliver and apply their messages. In that context, there is increasing demand for a re-examination of existing mandates that govern monitoring, the need to specify thematic areas of focus, and for NOS to lead by example. Activities such as the spatial data portal, a detailed requirements assessment centered on priority themes and coastal management questions, the development of a system-wide monitoring program for the National Marine Sanctuaries and the branding of NOS systems to increase public awareness represent substantive actions being undertaken by NOS that demonstrate its commitment to making a significant contribution to the IOOS vision.

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Index of Acronyms

ADCIRC	Advanced Circulation Model
CATS	Circulation Analyses Techniques
CBOFS	Chesapeake Bay Operational Forecasting System
CH3D	Chesapeake 3D Model
CO-OPS	Center for Operational Oceanographic Products and Services
CSC	Coastal Services Center
CSDL	Coastal Survey Development Laboratory
EFDC	Estuarine Fluid Dynamics Code
ELCIRC	Eulerian Lagrangian Circulation Model
ESI	Environmental Sensitivity Index
GNOME	General NOAA Oil Modeling Environment
HAB	Harmful Algal Bloom
HAZMAT	Hazardous Materials
IOOS	Integrated Sustained Ocean Observing Systems
LAPS	Local Analysis and Prediction System
LMR	Living Marine Resources
MECCA	Model for Estuarine Research Reserve System
NCCOS	National Center for Coastal Ocean Science
NERRS	National Estuarine Research Reserve System
NGS	National Geodetic Survey
NMS	National Marine Sanctuaries
NOAA	National Oceanic and Atmospheric Administration
NOS	National Ocean Service
OCRM	Office of Coastal Resource Management
OCS	Office of Coastal Survey
ORR	Office of Response and Restoration
PAR	Photosynthetically Active Radiation
PAH	Polycyclic Aromatic Hydrocarbons
POM	Princeton Ocean Model
TAP	Trajectory Analysis Planner
TCARI	Tidal Constituent and Residential Interpolation
VADM	Vice Admiral

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APPENDIX 1: NOS Operational Observing Systems

Program name	Description
Center for Operational Oceanographic Products and Services – CO-OPS	
National Current Observation Program	The National Current Observation Program (NCOP) is analogous to the National Water Level Program in that it is a network of historical observations of surface and subsurface collections stations covering most of the US coast. Updates are made through new observations and re-occupations over time. Funding limitations have prevented a systematic strategy to update old observations. In the 1970's there were two NOS vessels dedicated to regional and estuarine circulatory surveys and current meter deployments. Much of the recent historical data are from those surveys. There is a small rate of deployment using CO-OPS base funds and reimbursable partnerships ongoing. The main derived product of these observations are the NOS tidal current predictions. The only way to deterministically assess the adequacy of tidal current predictions is through the reoccupations of the historical sites.
National Water Level Observation Network	NWLON consists of 189 water level measurement stations distributed along U.S. coasts, in the Great Lakes and connecting channels, and in the U.S. territories and possessions. CO-OPS collects, processes and analyzes the water level and ancillary data (Meteorological/Oceanographic Data) from NWLON, producing standard time series and water level datum products. The NWLON is a fundamental building block of NWLOP. National Water Level Observation Program (NWLOP) is a network of operational and historical water level observation stations for which a national database of water level observations, tide and water level datums, bench mark elevations, and tide predication attributes are maintained and updated in a centralized manner. There are several thousand NWLP historical observation locations in the US Coastal Zone of varying time periods and record lengths. Each location is characterized and monumented with a local network of bench marks with published tide or water level datum elevations. Datum information and bench mark elevations are computed and updated using standard NOS national computation procedures and quality control procedures. Derived tide prediction products are found in tables 1 and 2 of the NOS tide prediction product suite.
Physical Oceanographic Real-Time System	PORTS provides ship masters and pilots with accurate real-time information required to avoid groundings and collisions, including real-time water levels, currents, and other oceanographic and meteorological data from bays and harbors. PORTS builds up NWLON local partnerships with the user community to maintain operations. PORTS represents a regional observing system concept operated under a national program strategy.
Coastal Services Center - CSC	
Benthic Habitat Assessment Mapping	Benthic habitats, including seagrasses (much of U.S. coasts), coral reefs (St. Croix and Hawaii) and unstructured sediments (e.g. sand and mud) (Appalachicola and Hudson NERRs) are mapped using a variety of techniques including satellite and airborne sensors, acoustic imaging, videography, photography, and benthic community analysis. These habitat maps establish baseline distributions and are used to assess change over time.
Coastal Change Analysis Program	C-CAP, in cooperation with partners, uses remote sensing (Thematic Mapper satellite) to classify land cover in coastal upland and wetland habitats of the United States, including the Atlantic, Pacific, Gulf of Mexico, the Great Lakes, Alaska, Hawaii, and all U.S. territories and possessions. Subsequent classifications are used to document changes in these resource areas and help coastal managers understand the consequences of changes.
Topographic Change Mapping – using LIDAR sensors	LIDAR is used to collect high-resolution topographic and other spatial data sets in response to the need for accurate, timely information on beach and dune field topography for the Pacific, Great Lakes, East Coast and Gulf Coast regions (in partnership with USGS and NASA). Products are used in coastal zone decision making processes.
National Centers for Coastal Ocean Science - NCCOS	
NS&T Benthic Surveillance	This program monitored chemical concentrations of over 70 organic and inorganic contaminants in the liver and metabolites of PAH's in the bile of bottom dwelling fishes and associated surficial sediment from coastal and estuarine waters of the Atlantic, Gulf of Mexico, and Pacific coasts, including Alaska from 1984 through 1993. Program was initiated to determine the current status of and to detect any long-term trends in the environmental quality of the nearshore waters of the United States. Contaminant exposure and bioeffects were monitored at more than 170 sites nationwide. Incidences of visible lesions were noted and histopathological examinations of selected liver, kidneys, fins, gills, ovaries, and testes were conducted. Expanded in 1987 to include measurements of biological effects due to contaminant exposure.
NS&T Mussel Watch	Determines concentrations of polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyl (PCB) congeners, several pesticides, butyltins, and certain toxic elements in sediment and bivalve samples from the coastal waters of the US in sediments and bivalve mollusks (i.e.., mussels and oysters). Presently, bivalve data are collected biennually and sediment data about every fifth year at a network of over 250 U.S. coastal and estuarine sites around the nation. Sites are selected to be representative of large coastal areas and to avoid small-scale patches of contamination, or "hot spots." Data can be used to compare contaminant concentrations across space and time to determine which coastal regions are at greatest risk in terms of environmental quality
NS&T Bioeffects Assessments	Studies to determine the incidence, severity, and spatial extent of biological effects of contamination in coastal waters. Studies consist of sediment toxicity surveys, evaluation and application of biomarkers, development of effect-based numerical guidelines to infer toxicological relevance of sediment contamination, and formulation of indices to describe the condition of the coastal ecosystems. Sediment toxicity surveys are conducted in specific coastal regions where contaminant monitoring data from the NS&T Program and other information from state and local sources, indicate that the potential for substantial environmental degradation and associated likelihood of biological effects exists. Studies are performed over a two-to-four year period. Sediment toxicity assessments are based on bioassays, impaired fertilization and larval development assessments, and measures of physiological stress. Biomarkers are being developed or tested to validate their field performance using endemic or transplanted bivalves or demersal fish.
Coral Reef Mapping	In partnership with DOI, NOS is beginning an effort to begin mapping U.S. coral reefs, starting in the Virgin Islands, Puerto Rico and Hawaii. Aerial photographs of the nearshore waters and used to create maps of the region's marine resources including coral reefs, seagrass beds, mangrove forests, and other important habitats for fisheries, tourism, and other aspects of the coastal economy. Benthic habitat maps will be produced directly in a GIS using visual interpretation of scanned aerial photographs, and a classification manual will be produced to document the specific methods used in image interpretation and habitat classification.
Coral Reef Monitoring	Monitoring to begin in September 2000, based on outcomes of design process with coral reef managers and scientists. The objective is to establish a nationally coordinated, long-term monitoring program for US coral reefs, consisting of new efforts linked strategically to ongoing monitoring programs worldwide. Initial monitoring will focus on priority habitat issues for reefs of particularly high value .

Harmful Algal Bloom Monitoring	Studies are being carried out at several sites in Maryland and Florida where blooms of Pfiesteria or Pfiesteria-like dinoflagellates have occurred in the recent past. Intensive short time-scale monitoring of a number of physical, chemical, and biological properties is being conducted. At two sites continuous monitoring systems have been established on buoy systems. These projects will obtain data used for characterizing and establishing causative relations related to blooms of certain harmful algal bloom organisms and for testing and evaluating improved monitoring methods.
National Geodetic Survey - NGS	
Coastal Mapping Program	The goal of the coastal mapping program is to survey the approximately 95,000 miles of coastline in the US and to provide the Nation with an accurate, consistent, up-to-date national shoreline. The method used today to delineate the shoreline is stereo-photogrammetry using tide-coordinated aerial photography controlled by kinematic Global Positioning System (GPS) techniques. This process produces a seamless, digital database of the national shoreline and a database of aerial photography.
Continuously Operating Reference Stations	The NGS) manages a network of continuously operating reference stations (CORS) that provide Global Positioning System (GPS) data in support of 3- dimensional positioning activities at the few centimeter level throughout the United States, its territories and selected foreign countries. These same GPS data serve to monitor the distribution of both the precipitable water vapor and electronically charges particles in the atmosphere and to monitor crustal motion (tectonic motion, earthquakes, subsidence, post-glacial rebound). Customers of the CORS system include land surveyors, GIS/mapping professionals, environmentalists, remote sensing professionals, educators, engineers, earth scientists, and meteorologists. The CORS program benefits from a multi-purpose cooperative endeavor involving many government, academic, commercial and private organizations. The CORS network currently (September 2001) includes a clooection of 229 "national" sites whose GPS data are directly available from NGS and a collection of 280 "cooperative" sites whose GPS data are available from partnering institutions.
National Spatial Reference System	The NGS defines and manages the National Spatial Reference System (NSRS) – the framework for latitude, longitude, height, scale, gravity, orientation, and shoreline throughout the United States. NSRS provides the foundation for transportation, communication and defense systems, boundary and property surveys, land records systems, mapping and charting, and a multitude of scientific and engineering applications. NGS also conducts research to improve the collection, distribution and use of spatial data.
Office of Ocean and Coastal Resource Management (OCRM)	
National Estuarine Research Reserve System – System Wide Monitoring Project	This system-wide Monitoring Program (SWMP) measures short-term variability and long-term changes in water quality and weather to contribute to coastal zone management. This program monitors a suite of water quality and weather information over a range of space (local, regional, national) and time (minutes, hours, days, months, years) in all twenty -five reserves. Water quality information collected includes pH, conductivity, temperature, dissolved oxygen, turbidity and water level. Weather data collected includes temperature, barometric pressure, relative humidity, wind speed and direction, solar radiation and rainfall. In addition, SWMP monitors nutrient and chlorophyll levels to assess eutrophication in the reserves. Future plans include adding a biological component and collecting data on land cover.
Office of Coastal Survey - OCS	
Hydrographic Surveying	Hydrographic Surveying focuses on the measurement and definition of the configuration of the bottoms and adjacent land areas of water bodies. The primary use of hydrographic surveys is for nautical charting, including the precise location of aids to navigation, dangers to navigation and, for inshore areas, the delineation of the shoreline and tide or water level measurements.
Office of National Marine Sanctuary (NMS)	
National Marine Sanctuary System	NOAA's National Marine Sanctuary System (NMSS) includes nearshore and open ocean waters at 13 locations that range in size from less than 1 to over 5,000 square miles. Protected habitats include rocky coasts, kelp forests, coral reefs, sea grass beds, estuarine habitats, hard and soft bottom habitats, segments of whale migration routes, and cultural artifacts. To date, monitoring has proceeded primarily on a site-by-site basis, with independent development of monitoring programs tailored to address at least some of the priority information needs of individual sanctuaries. Most efforts have been directed at selected "key resources" in the sanctuaries, and few sites have had the assets or means to monitor across a broad range of physical, biological and chemical regimes. At times, site monitoring has been designed to address specific issues, such as impacts of groundings, spills, cable installations, or hydrocarbon development, or the benefits derived from restricting use in certain areas (zoning). AN effort is currently underway to define and implement a system-wide monitoring program across sanctuaries: Channel Islands NMS; Cordell Bank NMS; Fagatele Bay NMS; Florida Keys NMS; Flower Garden Banks NMS; Grays Reef NMS; Monitor NMS; Monterey Bay NMS; Olympic Coast NMS; Stellwagen Bay NMS
Office of Response and Restoration (OR&R)	
Environmental Sensitivity Index maps	ESI maps contain information that NOAA collects on shoreline geomorphology in addition to biology and human-use information. The shoreline classification system was developed by OR&R and is the only consistent, nationwide classification available of the U.S. coastal zone. Shorelines in the lower 48 states, HI, and Puerto Rico are collected at 1:24,000. Shoreline data for Alaska are collected at 1:63360. The majority of the U.S. coastline have been classified in this manner. There are currently 3,349 ESI maps, covering 23 States, including the Virgin Islands, all 5 Great Lakes, Delaware Bay, and 7 river systems. In themselves, completed ESIs can be used to evaluate shoreline erosion potential, coastal storm vulnerability, and to monitor coastal change. Data from existing ESI maps can provide summary data, by county on the length of shoreline type in 10 major categories and the area of wetlands and tide flats. These summary data provide the only such summaries that can be used to inventory the U.S. shoreline geomorphology for coastal states. Standards for ESI maps are documented in Environmental Sensitivity Index Guidelines Version 3.0. NOAA Technical Memorandum NOS OR&R 11. On line at: http://response.restoration.noaa.gov/esi/guidelines/guidelines.html

APPENDIX 2: Survey of NOS Operational Monitoring Systems

Update of
NOS Inventory of Monitoring and Observational Programs and Capabilities
Please complete one survey form per program

1. Contact Information

Make corrections to the attached information.

Program Name
Principal contact for further information
Last name First name
Phone Ext.
Fax
E-mail
NOS Program Office
Division
Branch
Office Location

2. Program Description and Customers

Make corrections to the attached information and add who you consider to be your **primary** customers and any secondary customers or users.

3. Program Purpose

Indicate the primary and secondary (if appropriate) purpose of this observing program by checking the appropriate column. Also indicate if the program has an indirect benefit. Explain the rationale for your choice of secondary and indirect purposes.

C-GOOS Themes	Primary Purpose	Secondary Purpose	Indirect Benefit
Ensuring safe and efficient marine operations			
Mitigating natural hazards			
Protecting public health			
Ensuring the health of coastal ecosystems			
Assisting the management of living marine resources			
Detecting climate variability			
Ensuring sustainable coastal communities			
National security			

4. Program Scope

Would you consider your program(s) to be a national, regional, or local program in terms of spatial coverage and density and frequency of observations? Explain.

Is the information produced by your program used for national, regional or local decision-making? Give examples.

5. Observations Collected and Related Questions

Fill in the attached Table 1 as appropriate to indicate parameters
Collected, the monitoring/collection frequency, whether the data are
FGDC compliant, time to deliver the observations, and period of record

6. Use of Observations in Operational Models

Are any of the collected observations used in operational models? If so, please describe what how and what model(s) are used.

7. Observing Platforms

Indicate the platform(s) from which you collect observations (check all that apply):

NOAA Platforms:

NOAA aircraft	
NOAA ship	
NDBC platform/buoy	
NOS water level/tide station	
NOS current meter	
NOAA/NOS meteorological station	
NOAA/NOS wave buoy/system	
NOS GPS station/system	
NOAA satellite (includes GOES, POES and DMSP)	
Other NOAA assets, please specify	

Non-NOAA Platforms:

Commercial aircraft	
Autonomous aircraft	
Commercial ship	
University ship	
University buoy	
Commercial buoy	
USGS platform	
Autonomous Underwater Vehicle	
Other water level/tide station (please specify who "owns it")	
NASA satellite	
Military satellite (please specify the satellite name or operator)	
Foreign satellite (please specify the satellite name or operator)	
Other platform, please specify	

8. Leveraging Assets

Do you utilize partnerships/agreements with other federal, state or local agencies or private companies to densify the observations or provide increased frequency of observations/sampling? If so, please describe what is collected and the nature of the partnership.

9. Data Outputs and Availability

a. In what format(s) are the outputs of this program provided?

Hardcopy (microfiche, maps, imagery or photos, reports, etc.)	
Digital (on-line files, electronic spreadsheets or databases, CDs, etc). Please provide the url:	

b. Indicate the level of data processing prior to public release. Check all that apply.

Raw observations. What type of quality control/verification?	
Reviewed observations with more extensive quality control/verification	
Derived products such as maps, software routines, databases, etc.	
Other, please specify	

c. Identify how customers access your program's observations and outputs:

WWW Web page(s) (please specify url)	
Other electronic means (such as computer to computer, please specify)	
Customer order via phone, fax or Web page	
Other, please specify	

d. Web site demonstration – After you have returned this survey form, we would like to have you give the Survey Team a demonstration of your web site, focusing particularly on your data delivery capabilities.

10. Program Funding

a. In the next three years, do you foresee that funding for your program will (check one)? Explain if appropriate:

Increase	
Stay the same	
Decrease	

b. What do you estimate is the per unit cost to add another monitoring location to your program (express as a range in $k)?

c. If funding were increased, what locations or observations would you consider to be your top five priorities?

11. Monitoring Location

Please provide a GIS coverage or geo-referenced list of sites, or indicate on a map the locations of the observing/monitoring locations in this program.